



An Eclipse Based Software Solution for Space Mission Design

EclipseCon Europe 2011 – Philipp M. Fischer

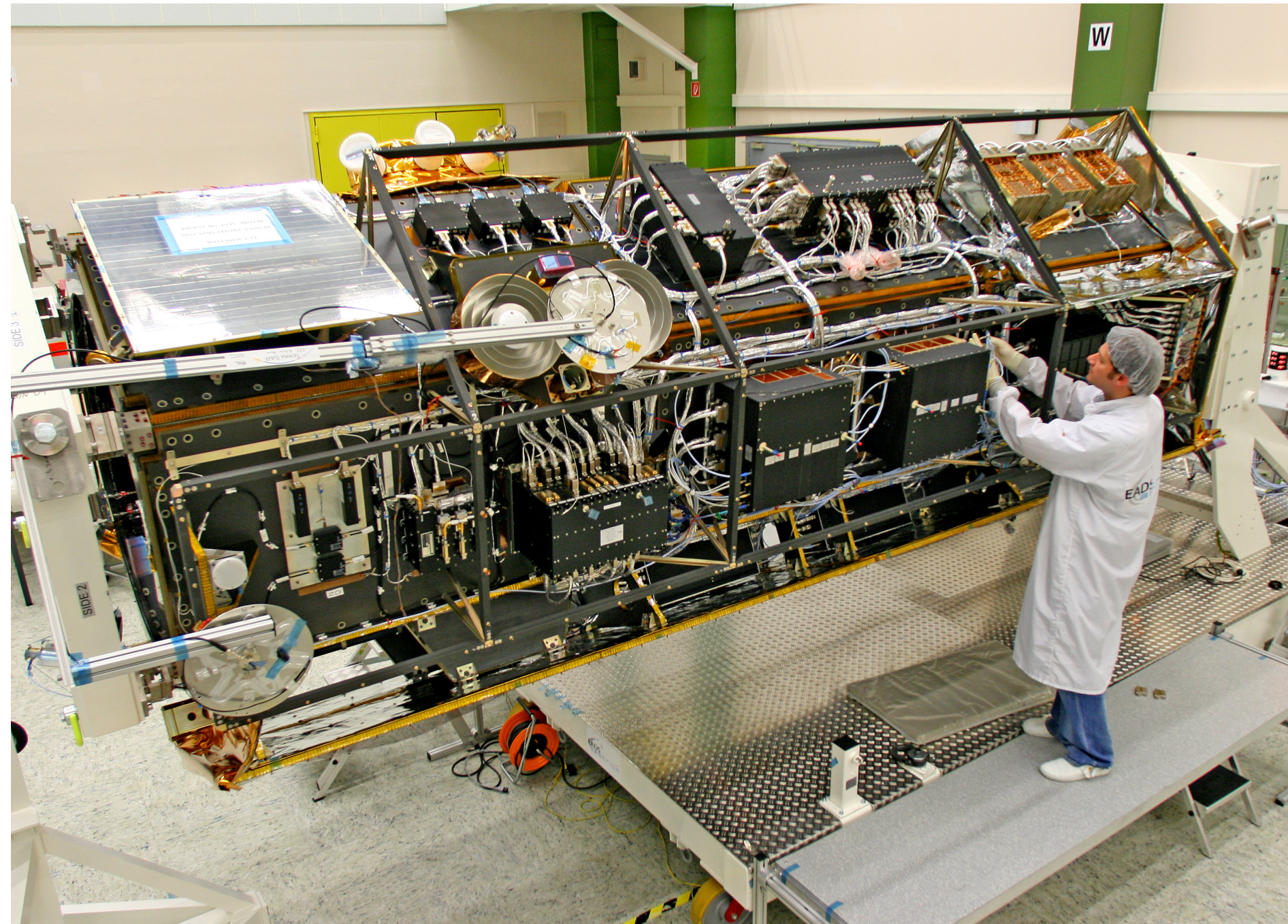
Today's Mission...

- A story about building spacecrafts...
- Building spacecrafts using Eclipse...
- A data model for spacecraft design...
- The good and the bad using Eclipse...



Building a Spacecraft is Complex...

- Knowledge of various experts
 - Power
 - Structure
 - Thermal
 - Propulsions
- Long term projects
 - Space shuttle
 - Mars rovers
 - ISS



Working in Parallel – The CEF

- Built in 2008 in Bremen
- Bringing the experts together
 - Estimating...
 - Weight
 - Power
 - Costs
- Roughly 14 days
 - 2 Sessions per day
 - Feasible results: +/- 15%



From Excel Sheets to Model Driven...

- Data provided as parameters
- The old way...
 - Modeled in Excel
 - Done by DLR, ESA, NASA
- The new way...
 - Modeled in Step – ECSS-E-TM-10-25
 - Modeled in EMF – Virtual Satellite

The screenshot shows an Excel spreadsheet with two tables. The first table, 'Solar Array Calculations', lists parameters like Required Power during Illumination (Pd), Required Power during Eclipse (Pe), Height (H), and Orbital Period (Earth, calculated) (T). The second table, 'Secondary Battery Calculations', lists parameters like Lifetime (Y), Charge Cycles (calculated) (Cyc), Required Power (estimated) (Pe), Depth of Discharge (DoD), System efficiency (n), and Required Battery Capacity (c_batt). A large blue arrow points from the Excel window towards the 'Virtueller Satellit' graphic.

Solar Array Calculations

Parameter	Symbol	Value	Unit	Remark
Required Power during Illumination	Pd	80,74	W	
Required Power during Eclipse	Pe	80,74	W	
Height	H	720	km	
Orbital Period (Earth, calculated)	T			
Orbital Period (estimated)				
Time of Eclipse				
Time of Illumination				
System Efficiency (Eclipse)				
System Efficiency (Illumination)				
Req. Solar Array Power (calculated)				
Solar flux				
Ideal Solar Cell Efficiency				
Ideal Power per m2				
Environmental Efficiency				
Worst Case Illumination Angle				
Power - Begin of Life				
Annual Degradation				

Secondary Battery Calculations

Parameter	Symbol	Value	Unit	Remark
Lifetime	Y	15	years	
Charge Cycles (calculated)	Cyc	1350		needs T (Earth)
Required Power (estimated)	Pe	115,3428571		Eclipse
Depth of Discharge	DoD	80	%	data sheet
System efficiency	n	70	%	data sheet
Required Battery Capacity	c_batt	154,4770408	Wh	needs Tc

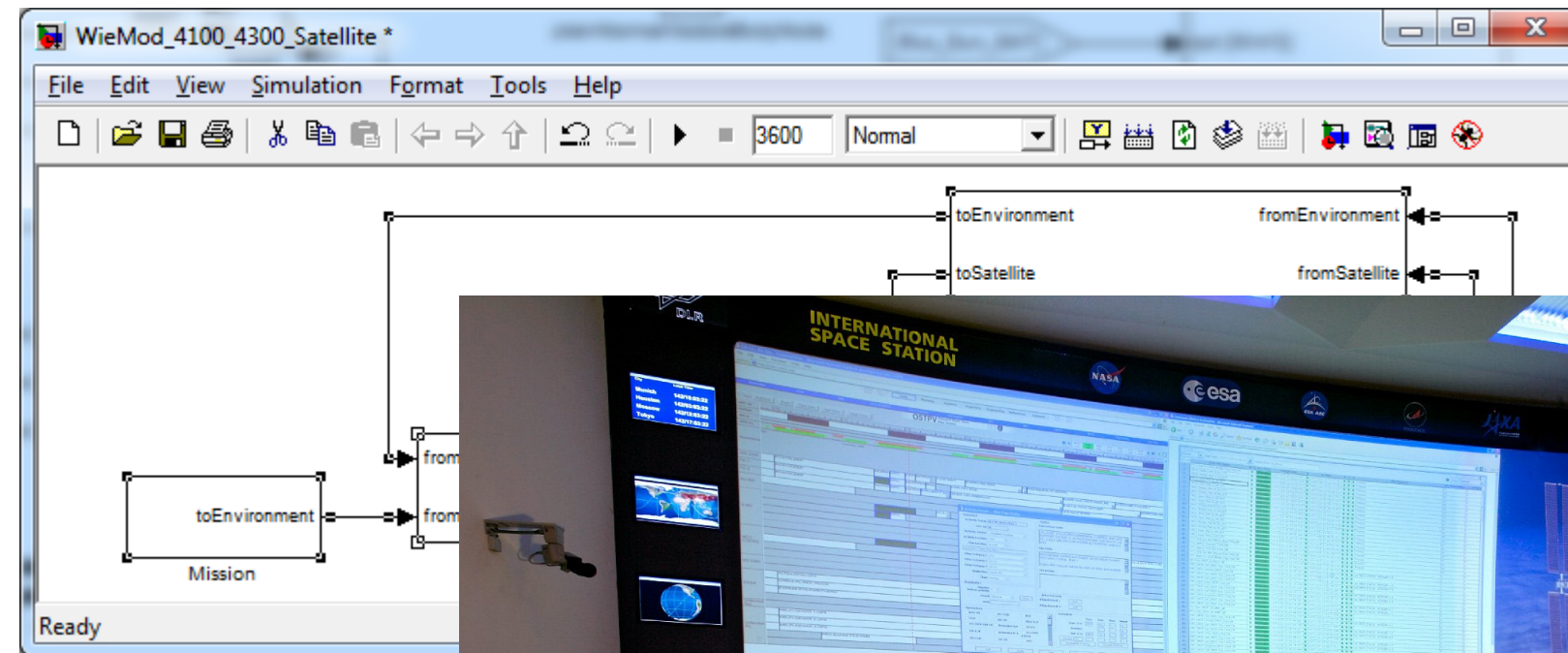
Virtueller Satellit

RCE

DLR

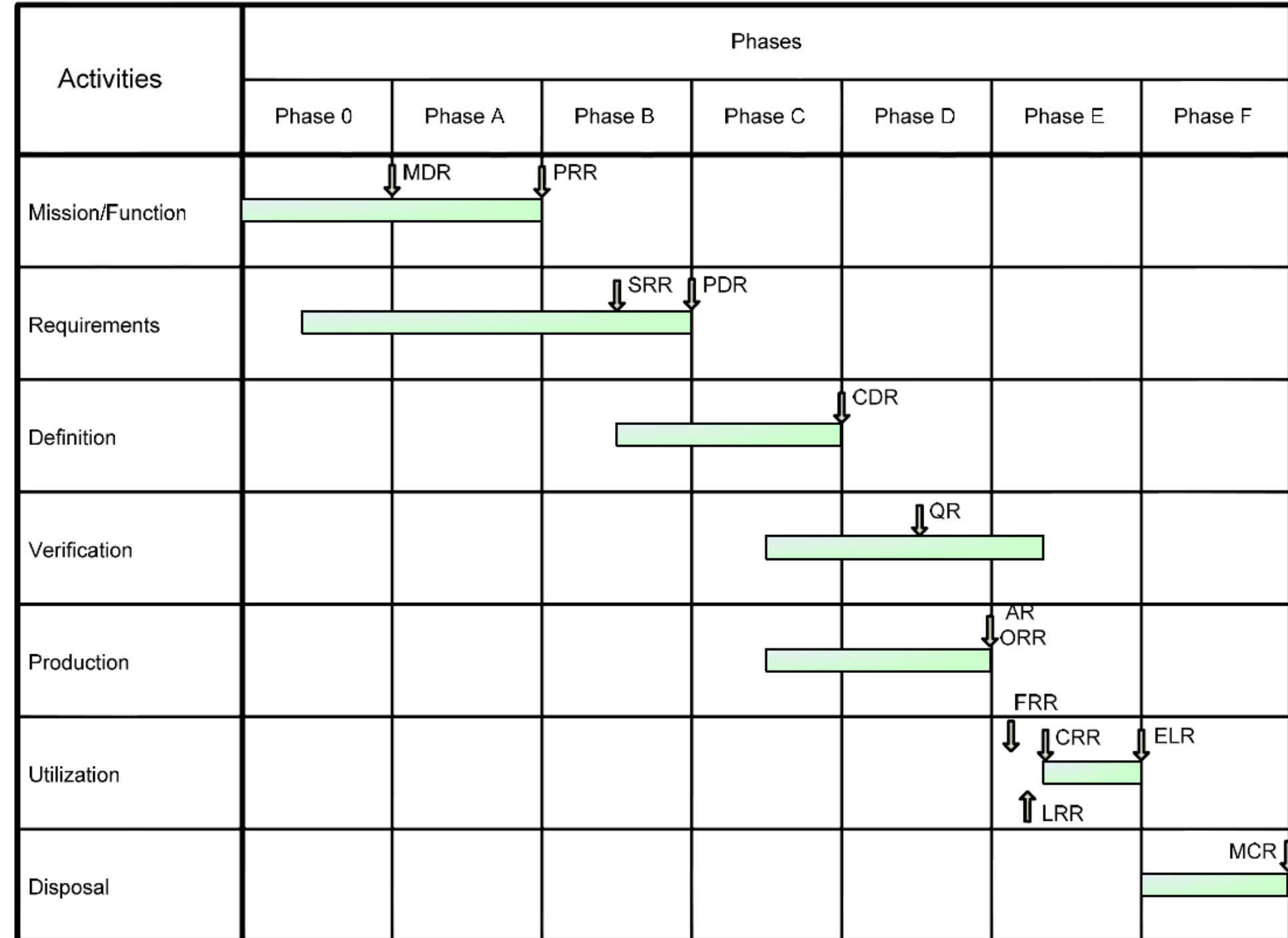
A Model Beyond the Early Design...

- It is not just parameters
 - Simulations
 - CAD
 - Commands
- Vision: Supporting the whole lifecycle
 - ECSS-TM-10-23 VSD
 - DLR Virtual Satellite



Virtual Satellite an Aerospace Design Tool

- Developed together with CEF
- Tool for spacecraft lifecycle
 - Phase A/B - Planning
 - Phase C/D - Building
 - Phase E/F - Operating
- Development in progress
 - Phase A/B in progress
 - Phase B/C just started



Phase A - N/A - Virtueller Satellit

File Edit Navigate Search Project Templates Window Help

Configuration Phase A Resource

Study Navigator Structure Computer StarTrackerBig Cover CON

IEEE2011_Library (disconnected)

- AHAB_Templates
 - AOCS
 - Propulsion
 - Sensors
 - Structure
 - BasePlate
 - LeftSide
 - Nose
 - RightSide
 - SolarPanelLeft
 - SolarPanelRight
 - TopPlate
- Role Management
- Unit Management
- IEEE2011_Study_1 (disconnected)
- IEEE2011_Study_2 (disconnected)
- IEEE2011_Study_3 (disconnected)

Name	Current Value	Unit	Shared	Description
visColor	16711680.000		no	N/A
visMassDry	7.200		no	N/A
visMassWet	7.200		no	N/A
visPositionX	0.000		no	N/A
visPositionY	0.000		no	N/A
visPositionZ	0.000		no	N/A
visRadius	0.010		no	N/A
visRotationX	0.000		no	N/A
visRotationY	0.000		no	N/A
visRotationZ	0.000		no	N/A
visShape	1.000		no	N/A
visSizeX	0.200		no	N/A
visSizeY	0.400		no	N/A
visSizeZ	0.400		no	N/A
visTransformationOrder	0.000		no	N/A
visTransparency	0.000		no	N/A

Parameters References Meta Data Excel

Repository Manager

Currently opened Repositories

Name	Proxy	Repository	No. Compone...	Changed	Connected
IEEE2011_Study_3	Subversion	Project	59 Components	no	no
IEEE2011_Library	Subversion	Project	41 Components	no	no
IEEE2011_Study_2	Subversion	Project	66 Components	no	no
IEEE2011_Study_1	Subversion	Project	62 Components	no	no

3D Mission and Configuration

And How it is Made...

- A productive software – not just science
 - 2 Engineers full-time
 - 1 Student part-time
- Agile project – DLR Software Process
- Quality procedures
 - Junit and Jubula
- Build Process – Continuous Integration
 - SVN, RepoGuard, Maven, Mantis, Jenkins ...

The screenshot displays two overlapping windows. The top window is the Eclipse IDE, showing the 'Plug-in Development' perspective. The Package Explorer on the left lists various project modules like 'com.ibm.icu', 'com.jcraft.jsch', and 'de.dlr.virsat.branding'. The main editor shows the 'RepositoryManager.java' file with its source code. The bottom window is the Jenkins web interface for the 'VirSat_Win7_x86_64' project. It features a sidebar with navigation links, a main content area with project details and a 'Disk Usage Trend' graph, and a 'Build-Verlauf' (Build History) table at the bottom.

Jenkins

VirSat » VirSat_Win7_x86_64

Projekt VirSat_Win7_x86_64

This is the Nightly build for the VirSat project. All the latest code of the SVN TRUNK will be used for the build.

Disk Usage Trend

disk usage (GB)

1

0

— build

— workspace

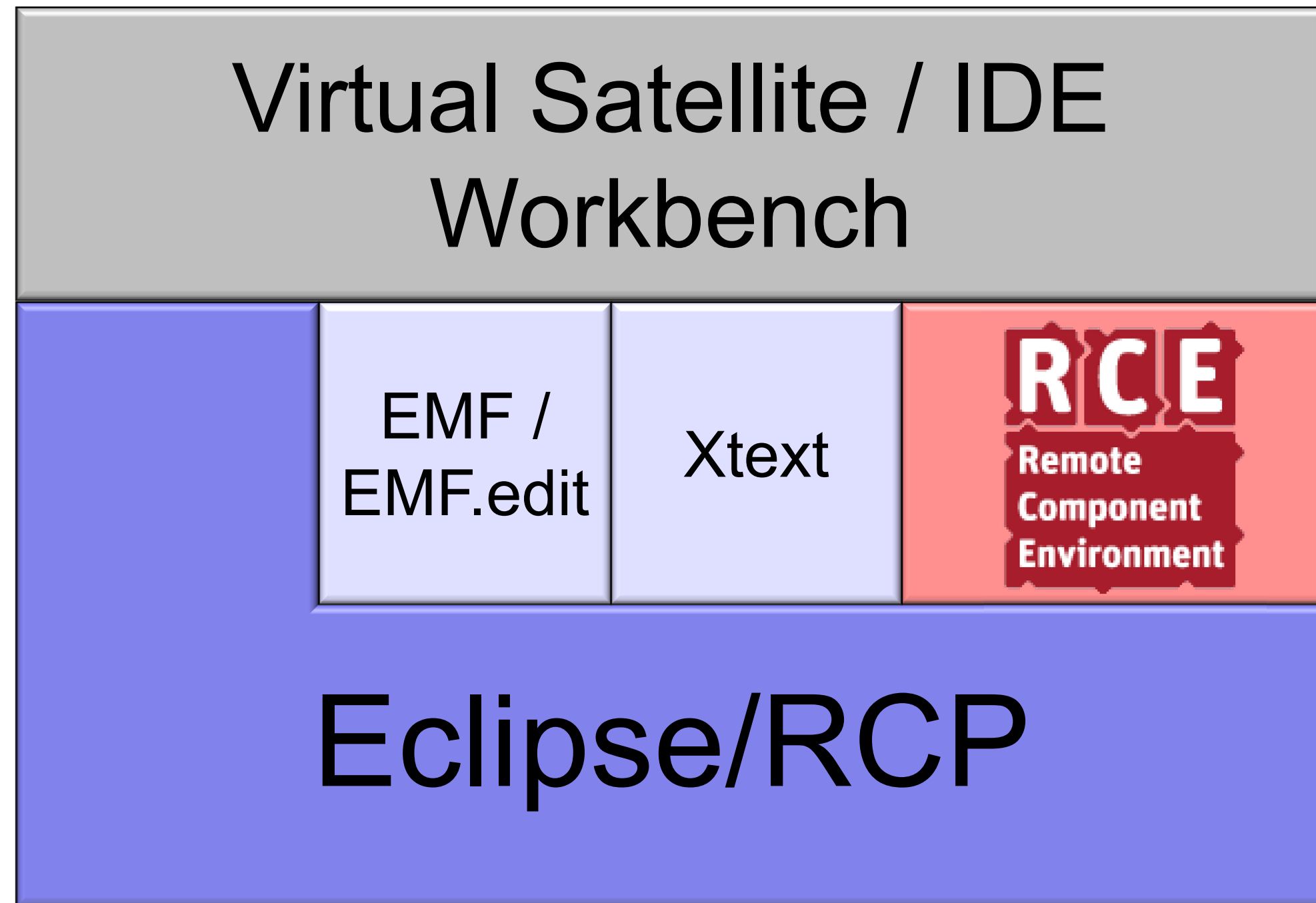
Permalinks

- [Letzter Build \(#11\), vor 2 Tage 13 Stunden](#)
- [Letzter stabiler Build \(#11\), vor 2 Tage 13 Stunden](#)
- [Letzter erfolgreicher Build \(#11\), vor 2 Tage 13 Stunden](#)
- [Letzter fehlgeschlagener Build \(#5\), vor 5 Tage 5 Stunden](#)
- [Letzter erfolgloser Build \(#5\), vor 5 Tage 5 Stunden](#)

Build-Verlauf	(Trend)
#11 29.10.2011 00:01:01 42MB	
#10 28.10.2011 00:01:09 42MB	
#9 27.10.2011 14:46:34 42MB	
#8 27.10.2011 11:53:02 42MB	
#7 26.10.2011 10:07:40 42MB	

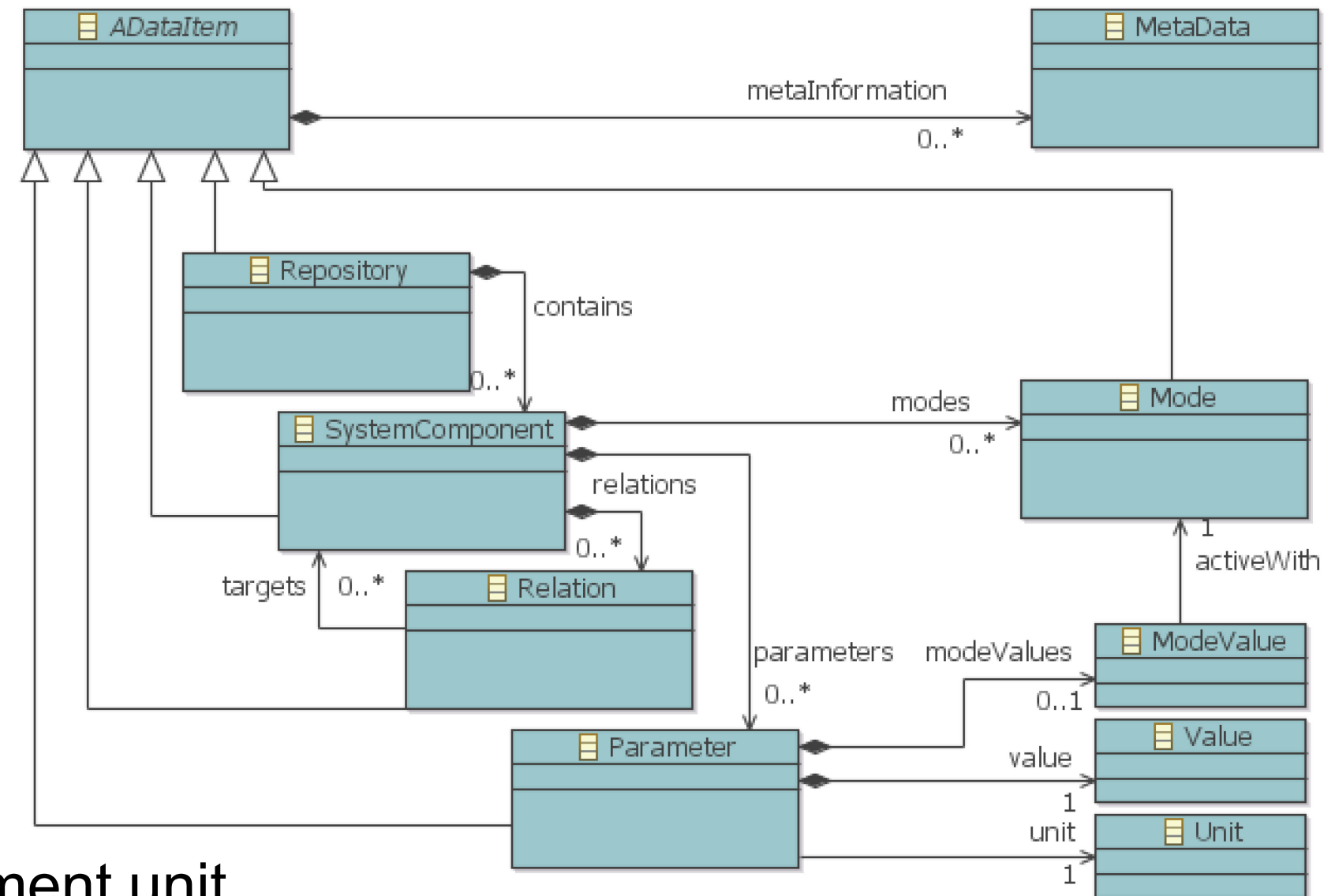
Virtual Satellite's Architecture

- Eclipse widely spread in
 - Academia
 - Industry
- Build on Eclipse RCP using
 - DLR-RCE
 - EMF
 - EMF.edit
 - Xtext



One Data Model for All

- One central data model
 - Common place of knowledge
- Modeling
 - Decomposition of spacecraft
 - Parameters for phase A/B
 - Calculations
 - QUDV
- Repository as central data management unit
 - Backend Interchangeable



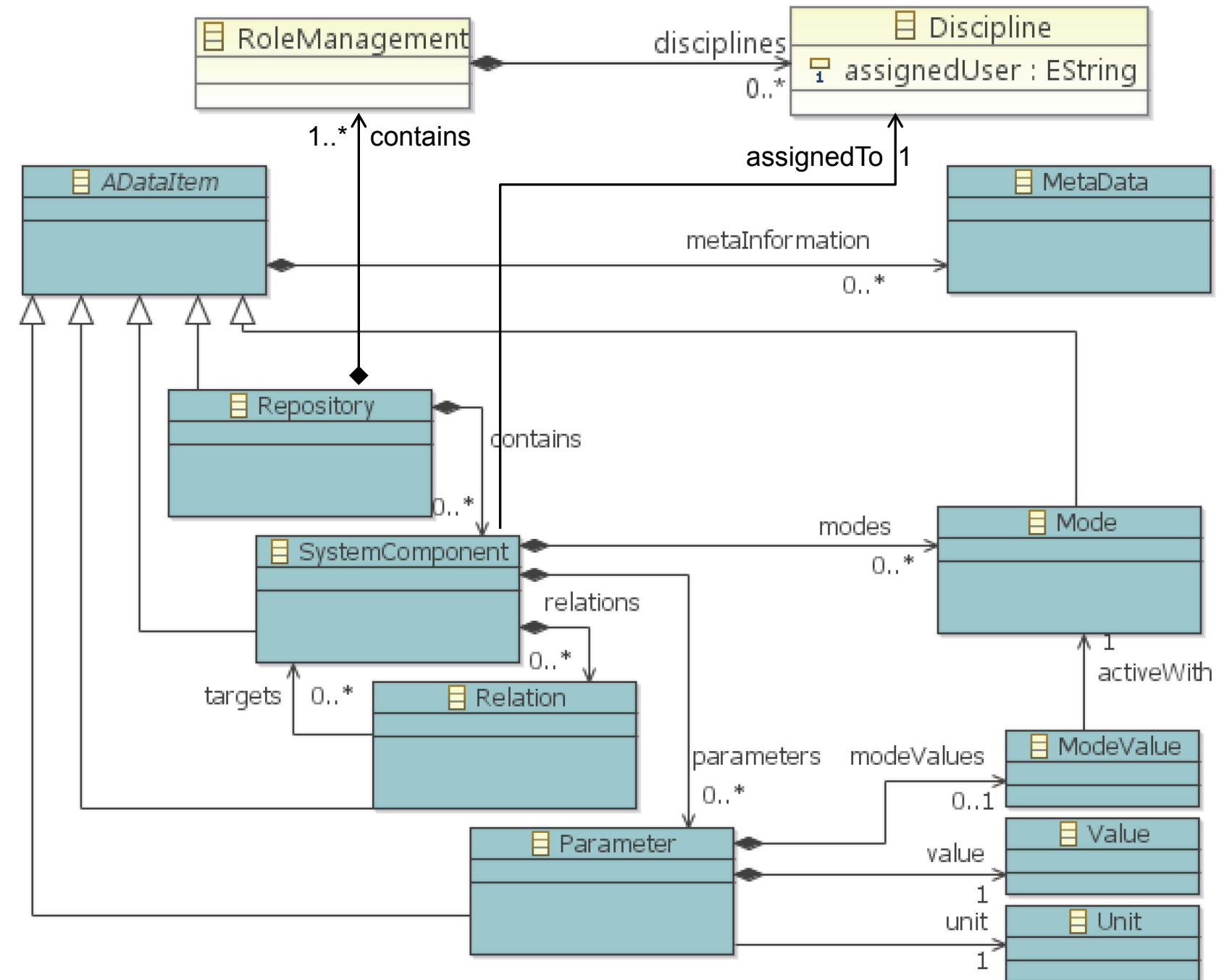
How to Get it Distributed?

- One data model
 - But multiple engineers
- Engineers used to SVN
 - Commit – Provide changes
 - Update – Obey changes
- Organizing read and write
- Avoiding merge conflicts



First Step – Who is Allowed to Modify the Data?

- Modeling Users
 - A Discipline
 - One User Name
- System Component
 - Applying one User
 - Sharing data areas
- Asking RCE LDAP for authorization
 - Granting permissions



Second Step – Serialization to Store the Data...

- Text for SVN Backend
 - Small changes in one session
- Using XMI
 - Provided by EMF
- So far writing as one resource
 - Multiple resources intended



```
73     </metaData>
74     <balancingsExcel id="88af3cf6-f7b5-4440-a92f-d3d244d9449e" />
75 </components>
76 <components id="04b0cf93-fab6-4b98-ab68-de57def2f29b" name="Computer" description="Computer" >
77     <parameters id="c61543f1-cf8f-4c36-8e3d-970930bfd8e7" name="visSizeX" description="N/A">
78         <value value="0.2" />
79     </parameters>
80     <parameters id="1723a3f1-d37a-4dd3-96e0-b7f197c2a729" name="visSizeY" description="N/A">
81         <value value="3.6" />
82     </parameters>
83     <parameters id="b3276f64-19ed-4908-be89-6d9e129a55" name="visRadius" description="N/A">
84         <value value="0.01" />
85     </parameters>
86     <parameters id="1cb9561d-bb60-4f58-a24f-827846146522" name="visColor" description="N/A">
87         <value value="16711680" />
88     </parameters>
89     <parameters id="5018b603-6463-43c2-aed9-a28e3d51832b" name="visPositionX" description="N/A">
90         <value />
91     </parameters>
92     <parameters id="81f177b2-d1e9-49b4-a0da-1b19afbd3676" name="visSizeZ" description="N/A">
93         <value value="0.1" />
94     </parameters>
95     <parameters id="06e70633-1fbc-4a77-982e-b8e926d7fedb" name="visSizeY" description="N/A">
96         <value value="0.2" />
97     </parameters>
98     <parameters id="d59407cd-3ed0-48c7-bc9e-59c00b6774fa" name="visShape" description="N/A">
99         <value value="1" />
100    </parameters>
101    <parameters id="e23c3611-e9be-40d1-b1b2-0ccc2850d63f" name="visPositionY" description="N/A">
102        <value value="0" />
103    </parameters>
104    <parameters id="debea5b3-c54b-44f4-8ae2-91a780e960ee" name="visRotationX" description="N/A">
105        <value value="0" />
```


Third Step – Separation for Mutual Units...

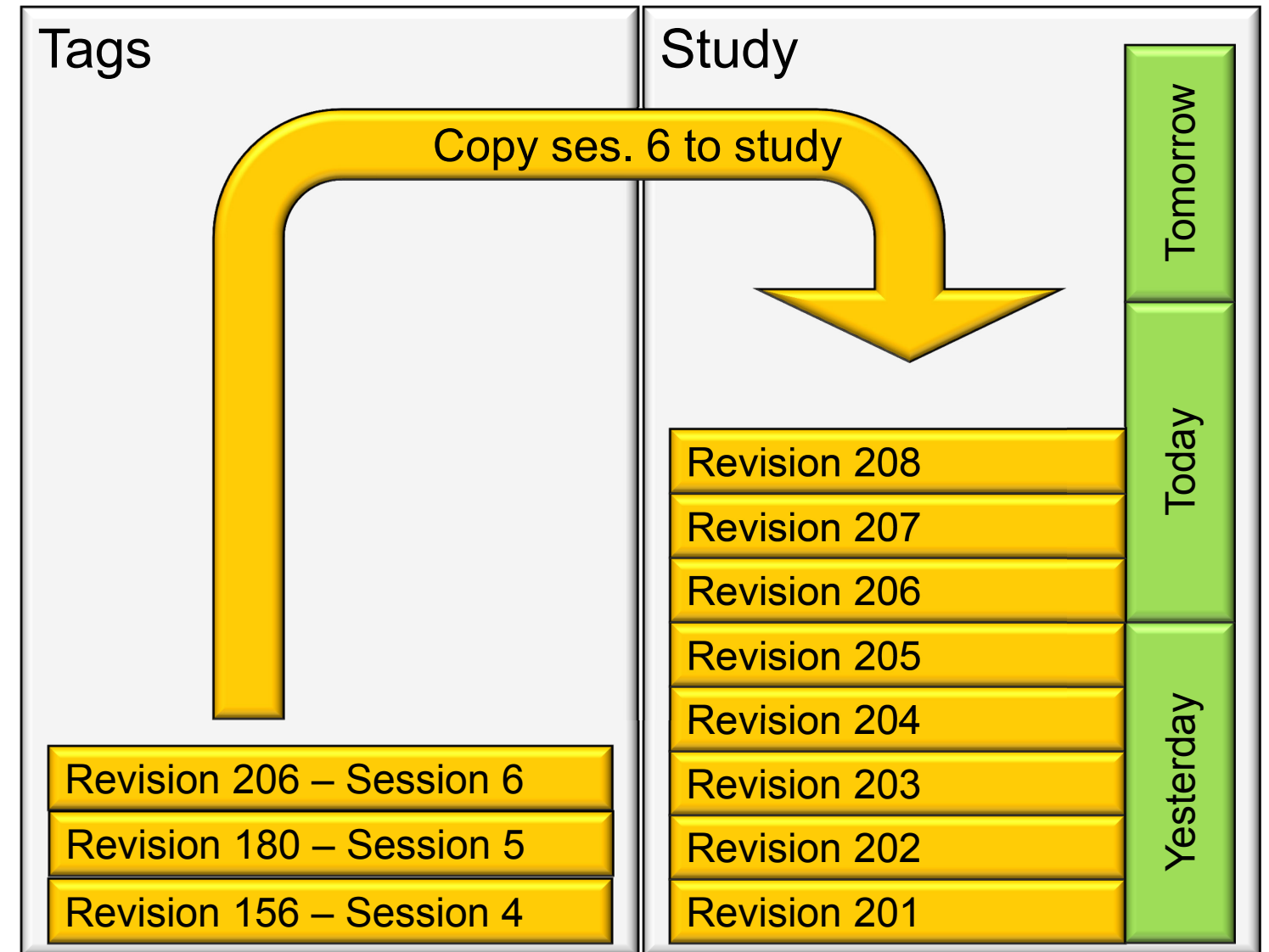
- Multiple files for SVN
- Separate files for System Components
 - No merge conflict since
 - One engineer per component
 - Each component one file
- Result: Just update / commit needed

```
73 </metaData>
74 <balancingsExcel id="88af3cf6-f7b5-4440-a92f-d3d244d9449e" />
75 </components>
76 <components id="04b0cf93-fab6-4b98-ab68-de57def2f29b" name="Computer" description="N/A" elementId=
77 <parameters id="c61543f1-cf8f-4c36-8e3d-970930bfd8e7" name="visSizeX" description="N/A">
78 <value value="0.2" />
79 </parameters>
80 <parameters id="1723a3f1-d37a-4dd3-96e0-b7f197c2a729" name="visMassWet" description="N/A">
81 <value value="3.6" />
82 </parameters>
83 <parameters id="b3276f64-19ed-4908-be89-6d9e129a552a" name="visRadius" description="N/A">
84 <value value="0.01" />
85
86
87
88
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94
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96
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102
103
104
105
```

Name	Änderungsdatum	Typ	Größe
IEEE2011_Study_Test_4.repository	18.10.2011 13:00	REPOSITORY-Datei	315 KB
StudyData_0c69f960-8c84-40cf-8716-0ab...	18.10.2011 13:00	PART-Datei	5 KB
StudyData_0dfa4f0c-3517-42b5-842f-76f6...	18.10.2011 13:00	PART-Datei	6 KB
StudyData_1e14dbf2-58bd-4bcc-8a94-57...	18.10.2011 13:00	PART-Datei	5 KB
StudyData_2dec63b6-fd70-474a-a4f3-e7e...	18.10.2011 13:00	PART-Datei	5 KB
StudyData_2e6293a2-624d-40a1-8043-4a...	18.10.2011 13:00	PART-Datei	5 KB
StudyData_3d2b0b7c-0059-4839-853d-82...	18.10.2011 13:00	PART-Datei	5 KB
StudyData_3f757f51-d4b8-4d60-81bf-76b...	18.10.2011 13:00	PART-Datei	5 KB
StudyData_04b0cf93-fab6-4b98-ab68-de...	18.10.2011 13:00	PART-Datei	5 KB
StudyData_4a48b086-ec8e-4689-844c-f0c...	18.10.2011 13:00	PART-Datei	5 KB
StudyData_4d68bc3c-2465-4b4f-abfd-8bf...	18.10.2011 13:00	PART-Datei	6 KB
StudyData_4d180025-9555-400f-b50e-ef2...	18.10.2011 13:00	PART-Datei	6 KB
StudyData_4dc4cc26-bc5d-40df-9175-9e...	18.10.2011 13:00	PART-Datei	5 KB
StudyData_4f9800bf-54de-4520-8a98-7e6...	18.10.2011 13:00	PART-Datei	5 KB
StudyData_05b3247d-6712-4e60-8720-04...	18.10.2011 13:00	PART-Datei	5 KB

Fourth Step – Storing it Version Controlled

- Using SVN
- Allows for version history
 - What happened yesterday
- Trunk/Tag/Branch
 - Not sufficient for us
- Centralized control needed
 - SVN internal copy as new Head-Revision



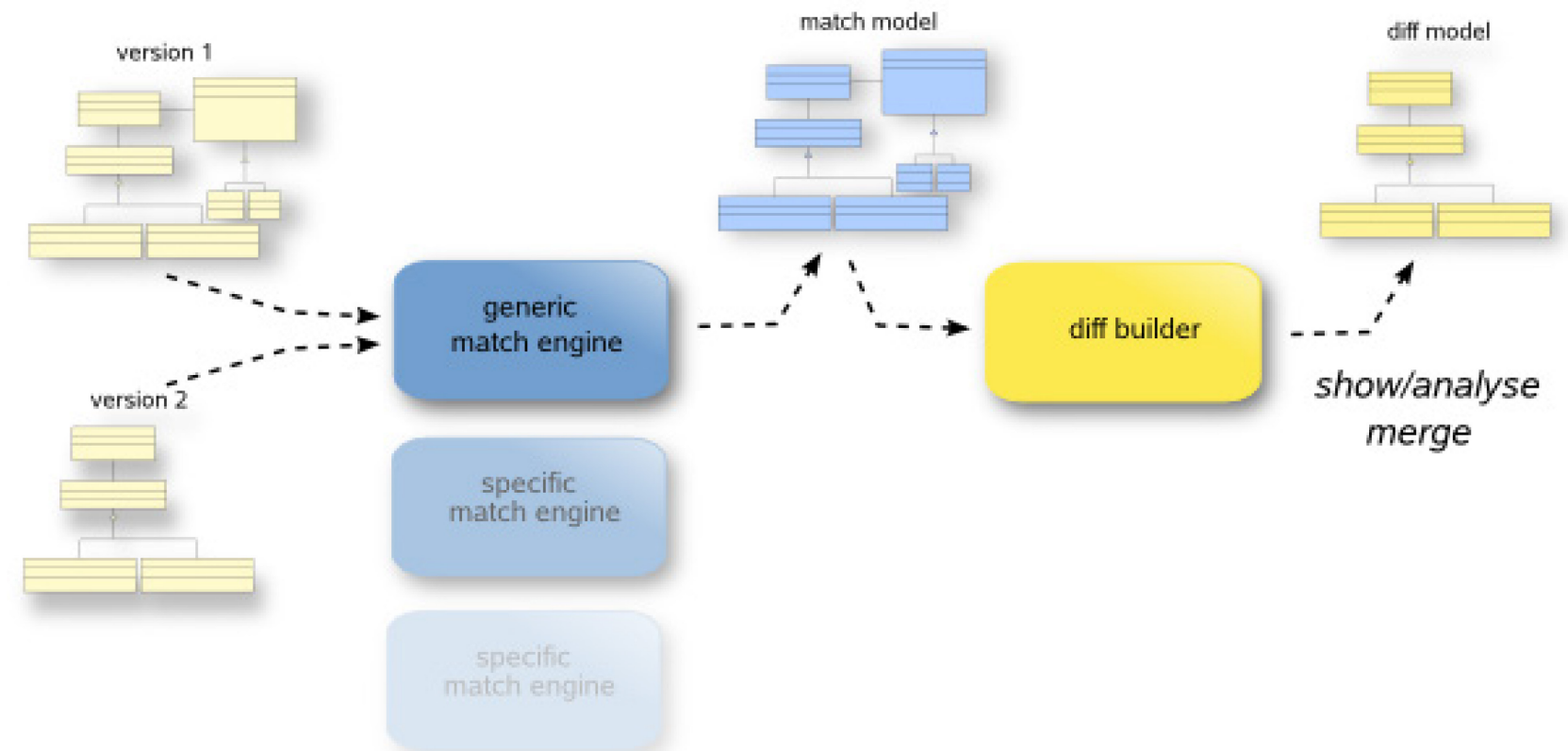
Why not Other Alternative Tools?

- What about CDO, Hibernate ...?
- So many good eclipse projects
 - But which one to use?
- There is little time for evaluation!
- Question of acceptance...
 - SVN is simple for engineers
 - SVN is simple for development

Eclipse Platform	✓	●	📖	📄	●	?
Debug	✓					
RelEng	✓					
Resources	✓			📄	●	
Runtime	✓					
SWT	✓	●	📖	📄		
Team	✓			📄	●	
Platform Text	✓	●		📄		
UA	✓	●				
UI	✓					
<hr/>						
Eclipse Modeling Project	✓	●	📖	📄	●	
Amalgamation	✓	●	📖	📄	●	?
Agent Modeling Platform	🥚	●	📖	📄	●	?
Eclipse Modeling Framework (EMF)	✓	●	📖	📄	●	?
CDO Model Repository	✓	●	📖	📄	●	?
EMF Compare	✓	●	📖	📄	●	?
EMF	✓	●	📖	📄	●	
Modeling Workflow Engine	✓	●	📖			
EMF Query	✓	●				?
EMF Query2	✓	●			●	?
SDO	✓		📖	📄	●	
EMF Teneo Model Relational Mapping	✓	●	📖	📄	●	?
EMF Transaction	✓	●				?
EMF Validation	✓	●				?
Eclipse Model Framework Technology (EMFT)	🥚	●	📖	📄	●	?
b3	🚫	●	📖	📄	●	
Doc2Model	🚫	●	📖	📄		

Eclipse the Bad Side...

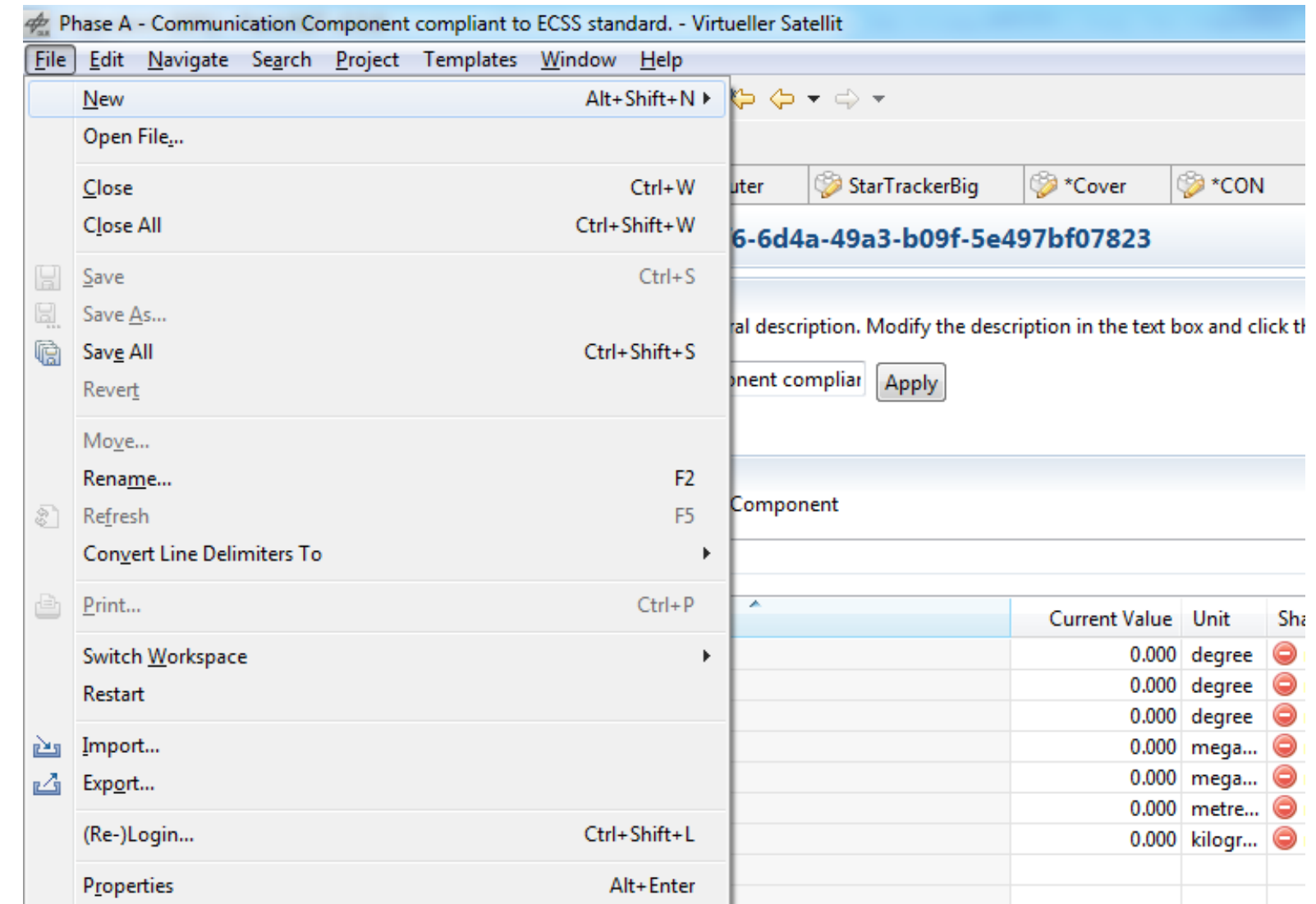
- Sometimes poor documentation
- Non appropriate examples
- EMF compare framework
 - Simple comparisons needed
 - 2 days of effort – No results
 - Developed our own comparison
 - Not even 1 day of effort !!!



selected SystemComponent				ECSS			
Shortname	Name - Description	Unit		Shortname	Name - Description	Unit	
ant_point_stab	Antenna Pointing Stability - Spac...	degree		ant_point_stab	Antenna Pointing Stability - Spac...	degree	
ant_steer_range	Antenna Steering Range - Spacec...	degree		ant_steer_range	Antenna Steering Range - Spacec...	degree	
fdown	Frequency Band Down - #th trans...	meg...		fdown	Frequency Band Down - #th trans...	meg...	
fup	Frequency Band Up - #th Transm...	meg...		fup	Frequency Band Up - #th Transm...	meg...	
elevangle	Ground Station Minimum Elevati...	degree		elevangle	Ground Station Minimum Elevati...	degree	
ss_harness_mass	Subsystem Harness Mass - Subsy...	kilog...		ss_harness_mass	Subsystem Harness Mass - Subsy...	kilog...	
max_freefall_distance	Maximum Freefall Distance - Max...	metr...		ss_harness_massmarg...	Subsystem Harness Mass Margin ...	perc...	
				max_freefall_distance	Maximum Freefall Distance - Max...	metr...	
Remove from selected SystemComponent				Add to selected SystemComponent			

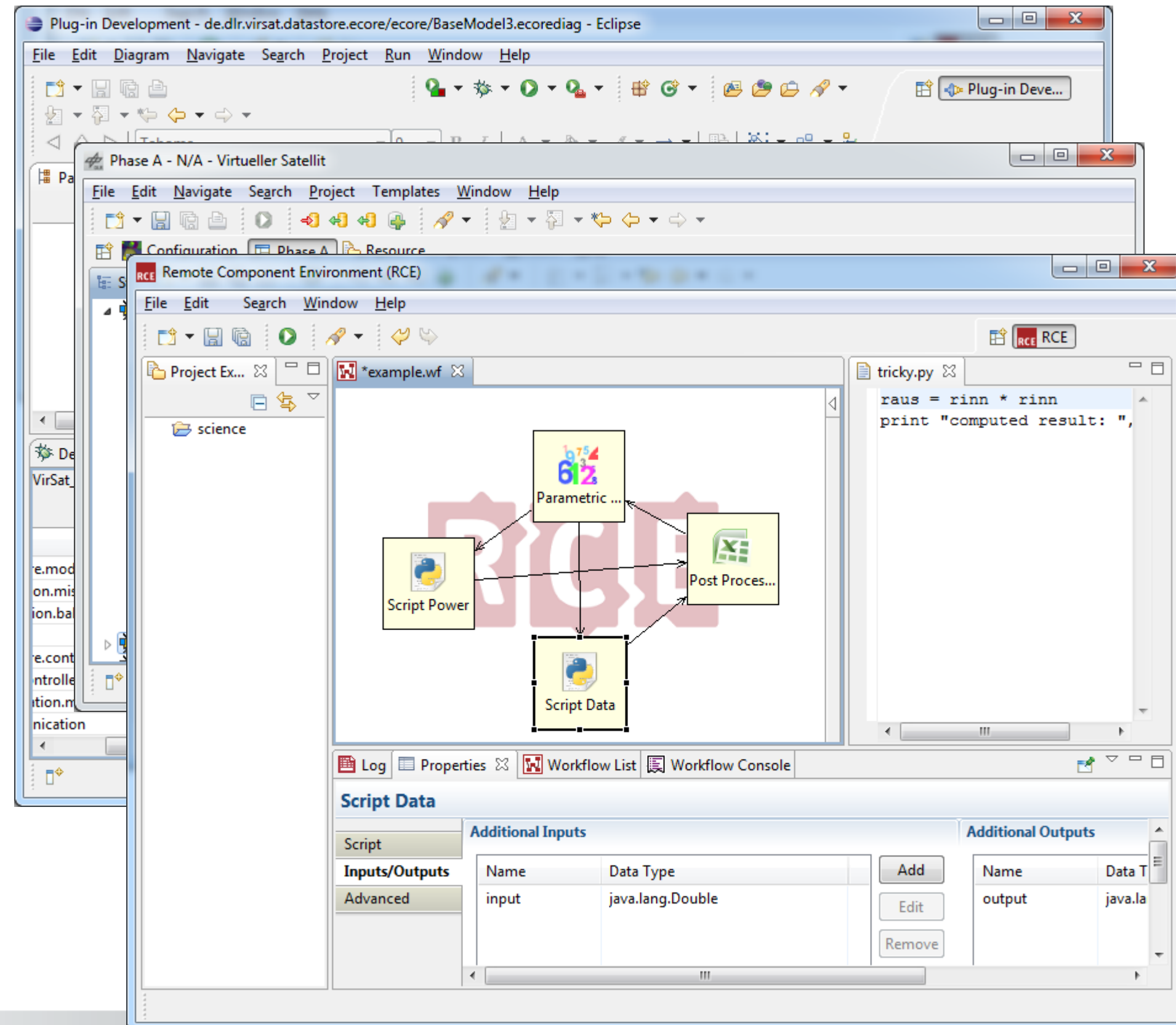
A Docking Maneuver to E4...

- Our current Eclipse version
 - 3.7 Indigo
- Our way to E4
 - Not many trouble expected
 - Changed to Command Framework
- Good experience with Command Framework but...
 - What about Ctrl-S - Still an Action...
 - What about Toggle-Buttons...



Eclipse the Good Side...

- A good tool for SW development...
- Many good tools for applications
 - Modeling Framework
 - Xtext
 - ...
- Many other projects
 - Integration on RCP level



Taking software engineering to space?

- Open source software engineering is concurrent...
 - It seems years ahead of the classical engineering disciplines...
- We already use Subversion as data storage backend!
- Why don't we use...
 - Mantis/Mylyn for traceability in the CEF design sessions?
 - Junit Test Runner for verifying simulation modules?
 - Equinox for component based simulations?

What Have we Seen Today...

- A little story of building a spacecraft. We have seen that a lot of different experts are contributing to such a design.
- An application to design spacecraft and to go beyond the early planning phase. All built on top of Eclipse RCP and EMF.
- Some good and bad aspects on using Eclipse. In particular the broad variety of projects and poor documentation is a main blocker for our developments.

See you soon...

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